

- ***Revise the Radio Standards and Procedures to make the regulations more flexible and to promote improved compliance.***
 - Work with representatives of labor and management to identify those aspects of the current rules that may discourage compliance because they lack flexibility.
 - Revise the regulations through a public proceeding.
 - Seek commitments from employee representatives and company officers to work for improved compliance with radio rules under revised standards.
 - Monitor compliance and strictly enforce the rules.
- ***Include in the proposed rule requirements that railroads provide suitable communications capabilities between trains and dispatchers, and between locomotive engineers and ground employees, and that back-up systems be established for critical functions.***
 - Propose that railroads develop and implement communication plans that address all safety-relevant functions.
 - Consider use of a wide range of technologies, including commercial options such as cellular telephone.
 - Review the number of layers of safety required for specific functions, considering the importance of the function to safety, the extent of daily reliance on the function, and the cost of the protection.
 - Recognize distinctions among rail passenger and freight operators and different operating environments, regarding the communications technologies that may be acceptable for primary reliance and the depth of safety redundancy warranted.
- ***Propose as a part of that rulemaking that each lead locomotive be equipped with an operative radio or suitable alternate communication equipment.***
- ***Work with a major railroad and its employees to implement transmission of movement authorities by digital data radio, in lieu of voice radio communications.***
 - Ensure that movement authorities are generated by the CAD system and issued directly to the on-board terminal.
 - Review changes in operating rules.

- Determine the most effective and secure means of providing hard copy authorities to crew members without transcription errors. Include an evaluation of on-board printers.
- Determine the feasibility of transferring concept to railroads employing other types of data communication technology.

POSITIVE TRAIN CONTROL

Signal and train control systems continue to serve the railroad industry with a high degree of reliability and enviable failsafe characteristics. Positive train control is the logical extension of those S&TC systems that do not yet provide PTC features. The railroad companies are beginning to recognize the opportunities presented by integration of data radio communications platforms and existing signal systems. Approximately half of the national rail system is not signalized, and this "dark territory" is particularly in need of supplementary safety systems.

Railroads recognize the need to move in the direction of positive train control, but, with limited exceptions, have not considered the necessary investments justified. For the near future at least, safety benefits will have to be accompanied by "business" benefits for PTC investments to make business sense for widespread application to freight lines.

The promise of ATCS has thus far failed to emerge--ironically, not because the railroad companies have clung to old ways, but because the railroads have moved ahead on a variety of fronts, utilizing alternative communication technologies to meet many of the needs ATCS was designed to meet. But the alternative technologies are not necessarily as suitable as a platform for train control functions as the ATCS digital data infrastructure. Thus, ATCS may not be deployed voluntarily on the basis of business requirements. For the immediate future, this means continued heavy reliance on voice radio for many communication functions.

A central communication-based approach to PTC remains the most likely path to safer train operations. In addition, that approach has the greatest chance of returning business benefits that can help pay for a portion of the communication infrastructure needed to support safety applications. Although the application of PTC on all rail lines would not be cost beneficial at the present time based on accident avoidance, PTC is required for high speed rail service and may be warranted on heavily traveled freight lines as well. Implementation of PTC that is interoperable will facilitate more widespread realization of safety and other benefits.

The absence of highly capable positive train control systems is a major factor limiting railroads' ability to serve the public. This study has refocused FRA's attention on the importance of promoting affordable positive train control. Consider:

- Antiquated train control limits system capacity.
 - Limited capacity could foreclose options for intercity and commuter passenger service on existing, heavily used freight lines (or unnecessarily increase capital and operating costs).
 - On some major freight corridors, downsized rail plants are now straining to handle increasing volumes of intermodal freight movements, as trucking companies and international brokers recognize the value of rail as part of the intermodal team. If freight capacity becomes a limiting factor, the ability of the railroad industry to relieve pressure on congested highways and to serve the Nation's environmental goals may be compromised.
- The cost of a highly capable positive train control system is a major element of any proposed high speed passenger rail system. New technologies offer the promise of lower cost. The cost of such a system might also be greatly reduced if part of a larger, interoperable design.

Given these stakes, fragmented decision-making by agencies of the Federal Government, the railroad companies, and rail suppliers is not acceptable. If planning is not coordinated, resulting train control systems may be wholly incompatible; or the cost of effecting interoperability may become too great to bear. Inevitably, this would lead to less effective systems on many of those lines where the need is greatest, since considerations of cost might require that nonequipped trains be allowed to intermingle with equipped trains.

FRA concludes that significant opportunities exist to promote the development of communication-based PTC. FRA also concludes that rail management will increasingly recognize the value of multi-purpose data communications platforms. Even where such platforms are not put in place quickly, railroads and their suppliers will develop innovative means of achieving PTC benefits in ways that offer adequate interoperability. Based on current forecasts for technology and service demands, FRA expects that the advantages of enhanced PTC systems with respect to train and crew management will result eventually in fully developed and integrated central communications systems.

Implementation of central communication-based PTC, the first choice of the freight railroads, will permit realization of safety benefits early in the migration to more capable systems, including reductions in demands on voice radio systems that are suffering from congestion and more secure transmission of movement authorities.

The Federal Government must play a constructive role as an investor, a facilitator and a regulator. Federal investments should be strategic—capable of meeting the broadest feasible range of functional requirements and appropriately linked to other Federal initiatives. The most competent PTC systems (such as Level 40 ATCS) promise increased capacity on existing rail lines and better precision to meet future service needs; and investments that are

coordinated in a way that results in maximum impact on all objectives will be most likely to satisfy Federal investment criteria.

FRA should continue to facilitate development by the private sector of PTC technologies. This role should include a strong emphasis on creating partnerships among the AAR, the railroad companies, established rail suppliers, the Federal Government, and defense industry suppliers seeking opportunities for conversion of technology to civilian use under programs administered by the Advanced Research Projects Agency, Department of Defense.

Regulatory action may also be appropriate to provide a level playing field for intramodal competition and to ensure prompt action to implement justified safety measures. In order to determine where investments in PTC may be warranted, it will be necessary to conduct a corridor analysis to examine risk characteristics (numbers of train movements, speed, passenger traffic, hazardous materials traffic). Should one or more categories of line segments stand out as presenting accident experience or future risk such that accident avoidance benefits would be greater than the cost of PTC implementation, rulemaking to require implementation should immediately follow.

Future Actions

In order to advance PTC, FRA will invest strategically, form and nurture partnerships with the industry to promote technical standards development, and aggressively prepare to exercise its regulatory responsibilities where justified by costs and benefits.

FRA will take the following actions:

- With funds requested in the President's Budget for Fiscal Year 1995, initiate development of a risk analysis model to guide determination of priorities (among major freight rail corridors) for application of PTC technology.
 - Determine cost/benefit ratio for application of PTC to priority corridors.
 - Consider factors pertinent to frequency and severity of preventable train accidents and incidents, such as train densities, passenger traffic, hazardous materials flows, etc.
 - Develop strategy for determining and applying trend lines to the analysis.
- Utilize results of risk analysis model and experience gained in review of Amtrak's enhanced ATC system for the Northeast Corridor to develop and issue a regulatory proposal requiring appropriate levels of PTC for applications where PTC is justified (including high speed rail).

Time line:

FY 1995 - Begin risk study.

FY 1996 - Complete risk study.

FY 1997 - Initiate rulemaking.

- Monitor the BN/UP pilot project for positive train separation, provide access to technical assistance available in the Federal Government, document the lessons of the project, and make recommendations to the AAR regarding future demonstrations and system implementation.
 - Working with the U.S. Coast Guard and the participating railroads, use this project to determine feasibility of differential GPS as a train location system on main lines both inside and outside rail terminal areas.
 - Determine cost implications of employing multiple data radio frequencies and communication software packages.

Time line:

FY 1995 - Monitor test bed development; work with UP/BN and AAR regarding
1996 interoperability, GPS, technology validation.

FY 1997 - Incorporate lessons in proposed rulemaking, if indicated by risk analysis.

- Support Amtrak's enhancement of its automatic train control system for the Northeast Corridor (NEC); issue performance criteria for operations to 150 miles per hour.
 - Propose S&TC/PTC safety requirements for NEC high speed operations to 150 miles per hour, taking into consideration the unique characteristics of that territory.
 - Refine issues for high speed PTC systems for later application in proposed generic high speed standards.

Time line:

FY 1995 - Conduct NEC S&TC/PTC proceeding.

- Work closely with the AAR to ensure that AAR's open architecture approach for universal compatibility remains effective and that standards meet safety needs.

Time line:

FY 1995 - Review report of AAR's tactical development task force. Provide feedback regarding safety competency issues posed by proposed approach.

FY 1996 - Work closely with UP/BN and AAR to incorporate test bed lessons into planning for AAR's positive train separation project.

FRA will also make and promote strategic Federal investments in the development and deployment of PTC and work with other Federal agencies to foster PTC, including the following:

- As proposed in the President's Budget for Fiscal Year 1995, include PTC as a major element in the technology development effort required for operation of high speed rail service over mixed passenger and freight corridors.

Time line:

FY 1995 - Initiate a project to assist in the testing and demonstration of PTC technology on a high speed corridor. Select corridor, determine technical approach, and begin system implementation.

FY 1996 - Complete safety verification of enforcement features.

FY 1997 - Enforcement features operative, transparent to operator; enhanced PTC working in the background.

Confirm adequacy of PTC for application to other high speed rail corridors.

FY 1998 - Implement enhanced PTC if consistent with regulatory findings.

- Work with the Federal Transit Administration to (i) evaluate the role that Federal capital investment in commuter rail service can have in hastening the development and deployment of PTC nationwide and in creating new capacity that would be available for commuter rail service; and (ii) assess relevant aspects of train control technologies applied to rail transit systems.

Time line:

FY 1995 - Complete review and determine need for Federal transit investment criteria specific to commuter rail signalization and train control.

FY 1996 - As indicated, propose any necessary regulations or legislation.

- Work with other DOT agencies and the Advanced Research Projects Administration (ARPA), Department of Defense, to promote integration of defense technology into PTC systems.
 - Work with the AAR, major railroad companies, and rail suppliers to form partnerships with defense suppliers and promote defense conversion in ways that enhance the capability and affordability of interoperable PTC.
- In partnership with the Federal Highway Administration (FHWA), implement the Secretary's Action Plan for highway-rail grade crossing safety by working together to plan for interface between PTC technology and Intelligent Vehicle Highway Systems (IVHS).

Time line:

FY 1994 - Conduct evaluation in connection with FHWA regarding PTC and the
1996 Vehicle Proximity Alerting System to provide grade crossing warning on high speed corridors, including use of the Transportation Test Center to perform evaluations of candidate technologies.

FY 1997 - Demonstrate IVHS and PTC interface for highway-rail crossing safety in cooperation with selected railroads and trucking companies.

- Work with other Department of Transportation elements to ensure that availability of highly precise, differential GPS navigation contributes to the cost effectiveness of PTC technology.
- Work with the DOT Office of Intermodalism and the Federal Highway Administration (FHWA) to determine the value to intermodal transportation of fully developed PTC technology that could provide increased capacity and service reliability on major freight corridors, where both rail and highway resources are approaching capacity.

Prior experience with widespread application of technology, particularly modern electronics, offers strong evidence that early success supports rapid deployment. FRA believes that this is particularly true with respect to PTC. Central control software for a communication-based system, for instance, may be capable of application to many rail properties, once created. As more and more locomotives are equipped with on-board equipment, the cost of extending PTC to additional territories will fall.

Initial steps may be costly, and technical challenges remain. Railroad companies will insist on technology that is reliable, since low reliability will disrupt service. However, as technical obstacles are overcome and initial investments are made across one or more rail systems, significant momentum will have been achieved. The UP/BN test bed, though by no means an answer to all pertinent questions, augurs well for an era in which theory will be translated into practical application. In addition, FRA will assist in development of enhanced

PTC technology suitable for high speed rail applications. If the signal engineers of the 1920s were able to create practical automatic train control systems, the future of contemporary PTC should be very promising.

FRA believes that private and public sector efforts can be combined to foster deployment of contemporary PTC systems on high-risk rail corridors by the year 2000. *FRA will make it a high agency priority to accomplish this objective.*

Glossary of Terms and Acronyms

AMERICAN SHORT LINE RAILROAD ASSOCIATION (ASLRA) - An organization of participating railroads that addresses issues of a common interest to short line operators, e.g., legislation, rulemaking, operating problems.

ASSOCIATION OF AMERICAN RAILROADS (AAR) - An organization of participating railroads that addresses issues of a common interest to the railroad industry, e.g., legislation and rulemaking; issuance of recommended practices for motive power and equipment, signal and train control systems, communication systems, and operating rules; and assignment of radio frequencies.

ADVANCED TRAIN CONTROL SYSTEMS (ATCS) - A microprocessor/communications/transponder-based system designed to provide both safety and business functions. Safety area capabilities are: (1) the digital transmission of track occupancy/movement authority to trains and an acknowledgement from the train crew via digital radio communications in lieu of voice communications, (2) provision of positive train separation control functions to preclude the train from exceeding its assigned limits of authority, (3) protection for maintenance-of-way and other workmen on track, (4) enforcement of authorized operating speed limits for trains consistent with civil engineering and other operating constraints, including temporary slow orders. In the business related function area, ATCS enables the transmission of work order activity related to pick-ups set-outs of individual and drafts of cars, locomotive health reporting, and other functions. ATCS is a joint program of the AAR and RAC.

ADVANCED RAILROAD ELECTRONICS SYSTEM (ARES) - An integrated command, control, communications, and information system which applies advanced avionics to the business of railroading. ARES generates efficient traffic plans, conveys them into movement instructions to engine crews and monitors actual train movements to detect deviations from plan. Designed to control rail traffic with a high degree of efficiency, precision, and safety. ARES communications flow through an automatic digital data link. The data link uses the railroad's existing microwave and VHF radio frequencies to communicate information, instructions, and acknowledgements between the control center and a train or other track vehicle. To determine position and speed, ARES uses the Global Positioning System (GPS) being deployed by the Department of Defense. On-board GPS equipment calculates vehicle position and speed, and the digital data link conveys the data to the control center. In addition ARES has the capability to be supported in part or totally by the strategic placement of transponder devices. The capabilities of ARES can be compared to those of ATCS. Developed and demonstrated by the Burlington Northern Railroad.

AUTOMATIC EQUIPMENT IDENTIFICATION (AEI) - A concept that provides the display of an electronic identification tag for rail equipment to be read by trackside scanners as the equipment passes. AEI is designed to provide timely, accurate data entry to railroad

computers for use as a management tool and customer service purposes, in the tracking of loaded and empty equipment.

ADVANCED CIVIL SPEED ENFORCEMENT SYSTEM (ACSES) - Program of the National Railroad Passenger Corporation (Amtrak). This system will use a carefully constructed blend of transponder scanning, radio, and microprocessor technology to meet specific needs of Amtrak's multiple-track, high-speed Northeast Corridor. Prototype testing and final specification for procurement of the ACSES system will be completed in 1995. ACSES will supplement the new continuous 9-aspect cab signal and speed control system by enforcing civil speeds at 5 mph increments up to 150 mph and by enforcing a positive stop at interlocking home signals where an overrun stop signal could compromise an adjacent high speed main track. It is being designed with a view toward ultimately equipping the entire Amtrak Northeast Corridor.

AUTOMATIC BLOCK SIGNAL SYSTEM (ABS) - A series of consecutive blocks governed by block signals, cab signals, or both, actuated by a train or engine, or by certain conditions affecting the use of a block, e.g., track circuit, control circuit, switch or derail position.

AUTOMATIC TRAIN STOP (ATS) - * A system supplementing an ABS or TCS system in which locomotives are equipped with a device so arranged that its operation will automatically result in the application of the brakes until the train has been brought to a stop in the event an engineer fails to acknowledge a signal that restricts the movement of the train.

AUTOMATIC TRAIN CONTROL (ATC) - * A system supplementing an ABS or TCS system of which locomotives are equipped with a device so arranged that its operation will automatically result in the following:

(a) A full service application of the brakes which will continue either until the train is brought to a stop, or, under control of the engineman, its speed is reduced to a predetermined rate; or

(b) When operating under a speed restriction, an application of the brakes when the speed of the train exceeds the predetermined rate and which will continue until the speed of the train is reduced to that rate.

AUTOMATIC TRAIN PROTECTION (ATP) - That subsystem within the automatic train control system which maintains safe train operation through a combination of train detection, train separation, and interlockings.

ASPECT - * The appearance of a roadway signal conveying an indication as viewed from the direction of an approaching train; the appearance of a cab signal conveying an indication as viewed by an observer in the cab.

BACKUP - An alternate means of accomplishing a function using software, hardware, circuits or operational procedures separate from those used for the primary method.

BACKUP SYSTEM - A redundant system that performs the principal functions of the primary system with minimum deviation from the performance of the primary system.

BLOCK - A length of track of defined limits.

BLOCK, MANUAL - * A block established manually by signal, timetable or mandatory directive.

BLOCK SIGNAL - * A roadway signal operated either automatically or manually at the entrance to a block.

BLOCK SIGNAL SYSTEM - * A method of governing the movement of trains into or within one or more blocks by block signals or cab signals.

BOOK OF RULES (OR OPERATING RULES) - A set of codified regulations governing the conduct of railroad transportation which defines signal indications, speeds and specific operating requirements.

BLOCK TERRITORY - Trackage equipped with a manual block system, automatic block system or traffic control system.

BLEEDOVER RADIO INTERFERENCE - A condition where the voice communications from an adjacent frequency causes an unscheduled disruption to a voice communication in progress.

CENTRALIZED TRAFFIC CONTROL (CTC) - A traffic control system operated from a central dispatching office.

COMPUTER AIDED DISPATCHING (CAD) - A computer-based dispatching system providing automatic train routing and in some installations, a paperless dispatcher environment. CAD contributes by guarding against the inadvertent conflicts in train movement authorities. CAD systems typically consist of computer hardware and specialized software programs designed for railroad applications. CAD systems may have enhanced existing TCS capabilities through a number of subsystems. Trains can be tracked and recorded automatically, and written movement authorities, where necessary, can be generated, recorded and filed completely within the computer system. These activities provide an added enhancement to train operations safety.

DEAD SPOT - A location where the transmission of radio is not always achieved for reasons of the presence of terrain, tunnels, low areas with heavy foliage, as well as locations with atmospheric or other conditions creating interference.

DIVISION - A defined territory of a railroad under the jurisdiction of a superintendent or manager of operations.

DARK TERRITORY - Trackage that is non-sigaled over which the movement of trains are governed by timetable, train orders/track warrants, or operating rules for the movement of trains in other than block signal territory.

MANUAL BLOCK SYSTEM (MBS) - A block or a series of consecutive blocks governed by manually-operated signals or by mandatory directives.

DIRECT TRAIN CONTROL - A method of operation wherein the train dispatcher issues mandatory directives to establish limits of train movement authority in a series of consecutive blocks that may be signaled or non-sigaled.

DIFFERENTIAL GPS - An application of the Global Positioning System in which a ground-based radio transmission is utilized to correct or calibrate the position determined by reference to satellite-based transmissions, increasing accuracy of positioning.

DIGITAL DATA RADIO - System for transmission of electronic data via radio.

ELECTRONIC DATA INTERCHANGE (EDI) - The transmission of electronic data regarding rail shipments among rail shippers and carriers.

FLAG PROTECTION - A method of manually protecting trains to avoid collisions during an emergency or unusual operating conditions.

FAIL SAFE DESIGN - A term used to designate a design principle of any system, the objective of which is to eliminate the hazardous effects of a failure by having the failure result in nonhazardous consequences.

GLOBAL POSITIONING SYSTEM (GPS) - A satellite-based radio navigation system deployed and operated by the Department of Defense which, when fully operational, provides highly accurate three-dimensional position, velocity, and time data to users worldwide.

INTEROPERABLE - As applied to signal and train control systems, including PTC, the ability which permits trains equipped with the same or similar systems to operate on all railroads interchangeably and automatically without hindrance, delay or additional on-board equipment.

INTERLOCKING - An arrangement of signals and signal appliances/systems so interconnected that their movements must succeed each other in proper sequence, train movements over all routes being governed by signal indications. Interlockings may be either automatically or manually controlled. Manual interlockings are controlled from an interlocking machine that must be operated for each train movement. Automatic interlockings are designed with inherent powers that function by means of electric/electronic circuits to perform the functions of a manual interlocking.

INTERLINE SERVICE MANAGEMENT (ISM™) - Railroad "industry level" systems development to foster the implementation of business processes and supporting information systems that will allow interchange of goods or passengers between carriers to provide (and support customers) reliable, competitive, seamless service. Due date late 1996.

INTERMODAL SERVICE - Carriage of a vehicle, container or passenger successively by two or more modes of transportation (e.g., ocean-going ship, railroad, air and highway). Involves transportation partnerships among differing transport modes - as between the highway mode, railroads, and transoceanic shipping.

INTERSTATE COMMERCE COMMISSION (ICC) - Independent agency of the United States Government responsible for designated transportation regulatory functions. Predecessor of the FRA with respect to administration and enforcement of the Federal railroad safety laws and regulations.

JOINT OPERATIONS - Railroad operations involving more than one railroad company, as at interlockings or other facilities jointly-owned, maintained or operated.

MAINTENANCE-OF-WAY (MOW) - Having to do with the installation and maintenance of track and related structures to facilitate the operation of trains.

METHOD OF OPERATION - The authority for the movement of trains, e.g. signal indications, timetable and train orders, track warrants, etc.

NATIONAL RAIL SYSTEM - The general system of rail transportation, consisting of interconnected trackage of all rail carriers that provide interline service.

NORTHEAST CORRIDOR (NEC) - That segment of tracks extending between Washington, D.C. and Boston, MA and certain connecting lines.

POSITIVE TRAIN SEPARATION (PTS) - As applied to the next generation of train control systems, e.g., ATCS, the application of technology to control the movement of trains in a manner that precludes the occurrence of collisions. This term has also been employed by the Union Pacific and Burlington Northern Railroads to denote a test program for positive train control on certain of their main lines in the States of Oregon and Washington.

POSITIVE TRAIN CONTROL (PTC) - As applied to the next generation of train control systems, e.g., ATCS, the application of technology in various subsystems that intervene to prevent trains from operating at a speed in excess of the maximum allowed, movement past any point of known obstruction or hazard, and movement beyond the limits authorized.

RADIO FREQUENCY SPECTRUM - The entire range of electromagnetic communications frequencies, including those used by radio, radar and television, administered by the Federal Communications Commission. Several frequencies have been allocated to the railroad industry for the transmission of voice and digital data in connection with railroad operations.

By agreement the AAR serves as the clearing house for assignment of voice radio channels in order to prevent radio interference among the users.

RAIL SAFETY ENFORCEMENT AND REVIEW ACT (RSERA) - Public Law 102-365, enacted September 3, 1992. Section 11 of this legislation set forth the mandate for this report.

ROAD MILES - Route miles of trackage over which a railroad provides service. (Compare number of track miles, e.g., one road mile of double track equals two track miles.)

SIGNAL INSPECTION ACT - Legislation contained in 49 U.S.C. 26 granting the Secretary of Transportation authority to require, among other things, the installation, testing, maintenance and repair of Signal and Train Control Systems.

RULES, STANDARDS, AND INSTRUCTIONS GOVERNING THE INSTALLATION, INSPECTION, MAINTENANCE, AND REPAIR OF SIGNAL AND TRAIN CONTROL SYSTEMS, DEVICES, AND APPLIANCES (RS&I) - Rules and regulations promulgated under the authority of the Signal Inspection Act that governs Signal and Train Control Systems.

SIGNAL INDICATION - The information (authorization or directive) conveyed by the aspect of a signal.

SIGNAL AND TRAIN CONTROL SYSTEM - A generic term used to reference existing types of signal systems, e.g., block signal systems; interlockings; automatic cab signal, trainstop and train control systems; and other protective devices.

TRAIN ORDERS - Mandatory directives governing the movement of trains.

TRACK WARRANT CONTROL - A method of operation wherein the train dispatcher issues mandatory directives (track warrants) to establish limits of train movement authority between fixed points on a segment of track that may be signaled or nonsignaled.

TRAFFIC CONTROL SYSTEM (TCS) - * A block signal system under which train movements are authorized by block signals whose indications supersede the superiority of trains for both opposing and following movements on the same track.

TRANSPONDER - A device encoded with an electronic message which, upon receiving a designated signal from an interrogator, emits a radio signal conveying its message in digital form. As applied with the transponder placed in the gage of the rail or on the wayside and the interrogator placed on a locomotive, this mechanism provides information about the identification, location and operating speed (from elapsed time) of trains in equipped territory.

WORK ORDER REPORTING - A business-related function of ATCS which provides communication between the crew of a train and a central point, by digital data radio, related to pick-up and set-out of rail cars at shipper and consignee locations and handling of cars at yards and terminals en route.

WAYSIDE INTERFACE UNIT (WIU) - An element of an ATCS field system providing the interface with switches, signals, grade crossings and other devices for continuous monitoring and communication of their status to the central control offices, locomotives and other users.

* Denotes requirements of the Code of Federal Regulations (CFR) at Title 49, Part 236 - RULES, STANDARDS, AND INSTRUCTIONS GOVERNING THE INSTALLATION, INSPECTION, MAINTENANCE, AND REPAIR OF SIGNAL AND TRAIN CONTROL SYSTEMS, DEVICES, AND APPLIANCES (RS&I).

Appendix 1

EXAMPLES FROM FRA'S FILES, ACCIDENTS AVOIDABLE THROUGH THE POSITIVE TRAIN CONTROL FEATURES OF ATCS

- CIVIL SPEED ENFORCEMENT
- POSITIVE TRAIN SEPARATION CAPABILITY
- DIGITAL DISPLAY AND CONFIRMATION OF OPERATING AUTHORITY

Accident	Cause	*Reported Damage	Fatalities/ Injuries
(1) Norfolk Southern, at Sugar Valley, Georgia, on August 8, 1990. Two freight trains collided head-on on single track.	Disregarded a stop signal when moving off a siding beyond the authorized limits, onto a main track and into an oncoming train.	\$1.8M	3 fatalities 3 serious 1 minor
(2) Burlington Northern at Lyons, North Dakota, October 19, 1990. A freight train collided with the rear of the train at rest. The derailling equipment struck another train on the adjacent track.	Failure to operate the train within the speed authorized by signal indication.	\$1.3M	1 fatal 0 serious 1 minor
(3) Atchison, Topeka and Santa Fe, at Corona, California, on November 11, 1990. Two freight trains collided head-on.	Failure to stop short of a signal displaying a stop indication.	\$4.0M	4 fatal 2 serious 0 minor
(4) Amtrak at Boston, Mass., on December 12, 1990. An Amtrak train derailed and struck a standing train.	Failure to reduce speed in time to negotiate a 30 mph curve. Entered curve at 76 mph derailling 3 locomotives and 7 occupied cars.	\$12.5M	0 fatal 14 serious 439 minor
(5) Norfolk Southern at Wolf Creek Jct. near Kermit, West Va. on April 24, 1991. A freight train derailed 2 locomotives and 9 cars of its train.	Failure to observe speed authorized for the train.	\$.2M	0 fatal 0 serious 0 minor

(6)	Burlington Northern and Chicago Northwestern, at Converse Jct., Wyoming, on June 19, 1991. A BN train collided with the rear of a CNW train.	Failed to operate in accordance with signal indication.	\$1.7M	1 fatal 1 serious 1 minor
(7)	Burlington Northern, at Ledger, Montana, on August 30, 1991. Two freight trains collided head-on under track warrant authority.	The crew of the offending train and the dispatcher failed to fully comply with the provisions of the rules governing track warrant authority.	\$10.7M	3 fatal 2 serious 3 minor
(8)	Norfolk Southern, at Knox, Indiana, on September 17, 1991. Two freight trains collided head-on.	Failure to stop short of signal displaying a stop indication.	\$3.0M	1 fatal 1 serious 0 minor
(9)	Amtrak operating on CSXT, at Palatka, Florida, on December 17, 1991. Passenger train derailed.	Failure to control the speed on a curve in accordance with a permanent restriction on speed.	\$1.2M	0 fatal 1 serious 63 minor
(10)	Norfolk Southern at Sadorus, Illinois, April, 25, 1991. A freight train collided with the rear of a train at rest.	While operating at excessive speed, failed to stop at a signal displaying a stop indication.	\$.2M	0 fatal 1 serious 4 minor
(11)	Burlington Northern, at Marshall, Minnesota, on December 28, 1992. BN train collided with 30 cars and two cabooses standing on a siding.	Failure of the prior crew to realign the switch for main track movement.	\$1.0M	0 fatal 1 serious 4 minor
(12)	CSXT and Central of Georgia at Talladega, Alabama, on October 3, 1992. A CGA train struck a CSXT train at a railroad crossing at grade.	Failure of a CGA train to stop at an interlocking signal displaying a stop indication. Contributing factor was excessive speed.	\$.2M	0 fatal 0 serious 5 minor

(13)	Illinois Central, at Fulton, Kentucky, on March 22, 1992. Two IC freight trains collided head-on.	Failure to comply with speed restriction and misunderstood train movement authority via radio.	\$.3M	1 fatal 0 serious 2 minor
(14)	North Indiana Commuter Transportation District (NICD), near Gary, Indiana, on January 18, 1993. A commuter passenger train collided (side raking) another NICD train.	Failure to comply with the limits established by signal indication.	\$.8M	7 fatal 2 serious 93 minor
(15)	Atchison Topeka & Santa Fe and Burlington Northern at Fairmount, Oklahoma, on February 21, 1993. The AT&SF train struck a BN train at a railroad crossing at grade.	Failure to stop short of a signal displaying a stop indication.	\$.8M	1 fatal 1 serious 2 minor
(16)	Burlington Northern and Union Pacific at Longview, Washington, on November 11, 1993. A BN train collided head-on with a UP train.	Failure of the BN train to operate in accordance with signal indication.	4.0M	5 fatal 0 serious 0 minor
(17)	Illinois Central, at Flora, Mississippi, on February 26, 1994. Two IC trains collided head-on.	Failure to stop at the limit of authority for a meet with the opposing train.	\$1.5M	1 fatal 2 serious 1 minor
(18)	Burlington Northern, at Norway, Nebraska, on June 8, 1994. A rear-end collision was followed by a raking collision.	Preliminary information suggests the failure of the striking train to operate in accordance with signal indication.	\$2.5M	2 fatal 0 serious 2 minor

* REPORTED DAMAGE TO FRA AS SHOWN ABOVE IS NOT INCLUSIVE OF ALL THE COSTS ASSOCIATED WITH THESE ACCIDENTS. RATHER, THE COSTS ARE LIMITED TO REPORTABLE RAILROAD PROPERTY DAMAGE.

Appendix 2

AN EVALUATION OF THE NORTH AMERICAN ADVANCED TRAIN CONTROL SYSTEM

PREPARED BY:

**U.S. DEPARTMENT OF COMMERCE
NATIONAL TELECOMMUNICATIONS AND INFORMATION ADMINISTRATION
INSTITUTE FOR TELECOMMUNICATION SCIENCES
BOULDER, COLORADO 80303**

June 28, 1994

PREFACE

This report was sponsored by the Federal Railroad Administration, U.S. Department of Transportation, under Interagency Agreement Number DTFR53-93-X-00074. The recommendations contained in this report are those of the authors, and should not be construed as official policy of the U.S. Department of Transportation or the Federal Railroad Administration unless so designated by other official documentation. Likewise, this document does not convey official policy of the U.S. Department of Commerce, the National Telecommunications and Information Administration, or the Institute for Telecommunication Sciences.

Federal Railroad Administration management and administration of this project have been provided by Mr. Gene Cox of the Office of Safety Enforcement.

The authors would like to acknowledge the cooperation of Mr. Howard Moody of the Association of American Railroads and engineers from ARINC Research Corporation in the completion of this project.

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EXECUTIVE SUMMARY

In 1992, Congress passed the Rail Safety Enforcement and Review Act. The Act directs the Secretary of Transportation to conduct a safety inquiry regarding Department of Transportation (DOT) railroad radio standards and procedures. The inquiry is to include assessments of:

- the status of advanced train control systems that are being developed, and the implications of such systems for effective railroad communications.
- the need for minimum Federal standards to ensure that such systems provide for positive train separation and are compatible nationwide.

Within DOT, the Federal Railroad Administration (FRA) is responsible for the assessments listed above.

The Association of American Railroads (AAR) and the Railways Association of Canada (RAC) have proposed a set of specifications for what is known as the North American Advanced Train Control System (ATCS). The ATCS is a communications-based system that transmits command and control information between dispatch centers, locomotives, track maintenance vehicles, and wayside devices. It is intended to lead to more economical, efficient, and safe train movement in North America.

To help assess the potential of the ATCS to provide for positive train separation, speed restriction enforcement, and other safety enhancement functions, FRA entered into an inter-agency agreement with the Institute for Telecommunication Sciences (ITS). ITS is part of the National Telecommunications and Information Administration (NTIA), U.S. Department of Commerce, and serves as a principal Federal resource for assistance in solving telecommunication problems of other Federal agencies, state and local governments, private corporations and associations, and international organizations.

ITS was tasked to study the ATCS Specifications and evaluate the system development process. This technical evaluation of the ATCS will help FRA complete the assessment required by the Rail Safety Enforcement and Review Act.

ITS has evaluated the ATCS based upon a review of the system's description as contained in the ATCS Specifications and other documents. Additional system information was obtained through discussions with ARINC Research Corporation, the engineering firm hired to develop the Specifications, with AAR and railroad industry representatives, and with railroad equipment manufacturers.

Conclusions

- 1) **The ATCS Specifications have been developed to ensure compatibility and interoperability.** The Specifications are written to ensure compatibility between system components produced by different manufacturers. They are written to ensure interoperability between railroads. Such compatibility and interoperability is needed to provide positive train separation throughout the North American rail system.
- 2) **The ATCS Specifications apply sound engineering techniques to ensure the proper delivery of data from source to destination.** Data communication systems must rely on automated techniques to ensure that data arrive at the intended destination, that errors are detected and corrected, that data have been protected, and that data arrive within established time constraints. The data communication system must have the ability to detect and recover from faults. In the event of failure, the data communication system must allow a graceful and safe return of control to a secondary system, in this case voice communication between the dispatcher and locomotives or track maintenance vehicles. The ATCS specifications describe a system which will accomplish these tasks well.
- 3) **The ATCS has the components to provide positive train separation.** Positive train separation refers to the capability to detect and prevent impending collisions between trains. Within the ATCS, the access of trains and track work crews to any section of track is strictly controlled by authorities issued by a dispatcher. The speed and location of trains and track work crews are continuously monitored. If violation warnings are not heeded by the operator, speed restrictions or the limits of movement authorizations are enforced through automatic brake application.
- 4) **The ATCS Control Flow Specifications need further testing and validation.** The ATCS Control Flow Specifications provide functional descriptions of certain aspects of railroad operating logic, and define how hardware and software elements of the system should interact in order to execute railroad operations. For example, one of the ATCS control flows describes the process by which central dispatch would issue a movement authority to a locomotive, and defines the associated messages that would be exchanged between various system processors.

A major revision of the Control Flow Specifications was completed in 1993. The control flows have become increasingly complex as system development has progressed, and ARINC is working on further documentation to aid ATCS software developers.

Because of the complexity of the control flows and because correct control flows are essential to safety, ITS recommends independent modeling and validation of the ATCS control flows under a variety of operating scenarios to ensure that the system functions as intended.

- 5) **A coordinated field test of a full implementation of the ATCS is needed.** Various railroads and railroad equipment manufacturers have implemented only portions of the ATCS Specifications, or have conducted only limited tests of ATCS applications and equipment. A coordinated effort is

required to field test a full implementation of the ATCS on a section of track with a variety of typical environmental conditions. A more comprehensive field test or pilot demonstration would be required to show that the ATCS can properly function in more severe environments such as the Chicago hub or the Northeast corridor with their more dense numbers of trains, urban conditions, etc.

6) A migration plan and a timetable for implementation of the ATCS is needed. A migration plan provides for an orderly transition from one system to another. The migration plan ensures that safety measures already in place are not removed before all trains that pass through the territory have fully-equipped ATCS locomotives. Older systems and the ATCS will probably have to be operated in parallel while the ATCS becomes fully operational.

The implementation timetable accounts for the acquisition of funding, the installation and testing of ATCS equipment, and training for users of the new system. The timetable should seek to accommodate all railroads to encourage widespread use of the ATCS.

7) A joint project that will have many of the ATCS features, as proposed by two railroads, needs to be evaluated and used to improve the ATCS. A press release on April 28, 1994, by the Union Pacific and Burlington Northern Railroads indicated the start of a joint project between the two railroads to develop the Positive Train Separation system with a pilot test program to be conducted on Union Pacific and Burlington Northern track in the Pacific Northwest. The preliminary descriptions of the joint project provide insight as to the scope of the effort. Many of the ATCS features will be retained with potential new ones added. The field tests and migration experiences will provide much of the knowledge requested in the last two conclusions listed above.

AN EVALUATION OF THE NORTH AMERICAN ADVANCED TRAIN CONTROL SYSTEM

Eldon J. Haakinson, Wayne R. Rust, and Martin M. Garrity¹

The railroad industry has proposed an advanced system for train control. This report presents an evaluation of the system development process, with particular emphasis on the data communication system that interconnects dispatch centers, locomotives, track maintenance vehicles, and wayside devices. The report describes the proposed train control system, establishes generic requirements for collision avoidance and telecommunication system development, and analyzes the system in light of the generic requirements.

Key words: advanced train control system; collision avoidance; data communication system; positive train separation; radio communication system; system architecture

1. INTRODUCTION

In 1992, Congress passed the Rail Safety Enforcement and Review Act [1]. The Act directs the Secretary of Transportation to conduct a safety inquiry regarding Department of Transportation (DOT) railroad radio standards and procedures. The inquiry is to include assessments of:

- the status of advanced train control systems that are being developed, and the implications of such systems for effective railroad communications.
- the need for minimum Federal standards to ensure that such systems provide for positive train separation and are compatible nationwide.

Within DOT, the Federal Railroad Administration (FRA) administers and enforces the Federal laws and related regulations designed to promote safety on railroads. FRA is responsible for the assessments listed above.

The Association of American Railroads (AAR) and the Railways Association of Canada (RAC) have proposed a set of specifications for what is known as the North American Advanced Train Control System (ATCS) [2]. The ATCS is intended to lead to more economical, efficient, and safe train movement in North America. The specifications have been developed over the last 10 years through an open-forum process involving contracted systems engineers, railroad industry professionals, and suppliers. The specifications define a telecommunication system architecture that accommodates the

¹ Mr. Haakinson and Mr. Rust are with the Institute for Telecommunication Sciences, National Telecommunications and Information Administration, U.S. Department of Commerce, Boulder, Colorado 80303. Mr. Garrity was formerly with the Institute.